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Categorisation of visualisation methods to support the design of Human-Computer Interaction Systems

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ABSTRACT

During the design of Human-Computer Interaction (HCI) systems, the creation of visual artefacts forms an important part of design. On one hand producing a visual artefact has a number of advantages: it helps designers to externalise their thought and acts as a common language between different stakeholders. On the other hand, if an inappropriate visualisation method is employed it could hinder the design process. To support the design of HCI systems, this paper reviews the categorisation of visualisation methods used in HCI. A keyword search is conducted to identify a) current HCI design methods, b) approaches of selecting these methods. The resulting design methods are filtered to create a list of just visualisation methods. These are then categorised using the approaches identified in (b). As a result 23 HCI visualisation methods are identified and categorised in 5 selection approaches (*The Recipient*, *Primary Purpose*, *Visual Archetype*, *Interaction Type*, and *The Design Process*).

1. Introduction

As a discipline, Human-Computer Interaction (HCI) has historically involved people from different fields (Lazar et al., 2010; Wania et al., 2007; Seffah et al., 2005; Carroll, 2003; Adamczyk and Twidale, 2007). Even though designing with people of varying background and expertise can help bring different perspectives together to generate new ideas (Rogers et al., 2011), it can also hinder the collaboration if the team members are restricted by discipline language and design approaches (Haesen et al., 2010; Mendel, 2012). The application of visualisation methods is widely discussed as a way to overcome the challenges of collaborative design (Bryan-Kinns and Hamilton, 2002; James Pierce, 2014; Zimmerman et al., 2007).

This paper adopts the definition of Lengler and Eppler (2007, p.1) and defines a visualisation method as "… a systematic, rule-based, external, permanent, and graphic representation that depicts information in a way that is conducive to acquiring insights, developing an elaboration understanding, or communicating experiences."

The adoption of visualisation methods in design has a number of advantages, including:

- *Visualising something externalises your understanding*

Externalising internal understanding aids the sharing of knowledge. This is important in two ways. Firstly, the adaptation of physical prototypes and sharable tools within a design team can lead to more successful methods in design (Jang and Schunn, 2012). Secondly, the creation of visual artefacts acts to elicit information from users, which may otherwise be difficult to capture (Sanders and William, 2003).

- *Visual artefacts help to store mental representations physically*

Creating a visual artefact helps to relieve a person's working memory (Tversky and Suwa, 2009), therefore improving thinking capacity. Furthermore, the act of visualisation could provoke the creation of new ideas (Fallman, 2003) or refinement of a design (Römer et al., 2001).

- *Visual artefacts can group together relevant information*

Abbreviations: HCI, Human-Computer Interaction; UCD, user centric design; SD, Service Design; IxD, Interaction Design.

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Grouping together relevant information can clarify how ideas and concepts are related (Tversky and Suwa, 2009). This reduces the effort, which would otherwise be required to search for elements to make problem-solving inferences (Larkin and Herbert, 1987).

The purpose of employing a visualisation method is not simply to create an image or object; the challenge is to provide relevant information that furthers the design process (Houde and Hill, 1997). In fact, creating an artefact which does not assist a designer to communicate or develop their ideas in a useful way is "useless, incomprehensible, confusing, worse than no image at all" (Arnheim, 1969). Whether or not relevant information is provided can be affected by the expertise of the designer (Haesen et al., 2009; Self et al., 2014) as well as their awareness and understanding of available design methods (Weevers and van Kuijk, 2012).

As HCI matures, there is an increasing demand to support selection amongst the growing number of design methods (Bryan-Kinns and Hamilton, 2002; Houde and Hill, 1997; Tidball et al., 2010). Current selection tools tend to focus on a facet of HCI methods, such as usability (Usability Net, 2006), UCD (Royal College of Art, n.d.; Weevers and van Kuijk, 2012; Maguire, 2001), and Service Design (Mendel, 2012; Tassi, 2009; Segelström and Holmlid, 2011; Stickdorn and Schneider, 2010; Alves and Nunes, 2013). To date, no research has been attempted to assemble a collection of HCI visualisation methods. A rare example of a visual-based selection tool is the periodic table of visualisation methods created by Lengler and Eppler (2007). They compiled over 100 visualisation methods and organised them into a periodic table format. Designers can make a selection based on a number of aspects, such as the complexity of the method and how similar they are to each other. These methods, however, are for management purposes and not HCI design.

To fill this gap, this paper reviews the categorisation of visualisation methods used in HCI. The authors seek to establish an inventory of HCI visualisation methods and identify ways of electing amongst them. Creating the inventory of HCI methods would enable designers to discover and learn about methods that they may have not used before or be familiar with. Categorising the methods provides a structure for new and experienced designers to determine appropriate methods for their design project.

This paper is organised as follows. Section 2 details the research methodology of how HCI visualisation methods and selection approaches are derived and categorised. Section 3 presents the resulting methods and selection approaches identified and the categorisation of the methods in each approach. Section 4 discusses the results and future work. Section 5 provides the conclusion.

2. Methodology

The goal of this methodology is to 1) establish existing HCI visualisation methods, 2) establish selection approaches, 3) categorise the visualisation methods identified. Fig. 1 presents a two-phase research methodology. Phase 1 is a keyword search of literature consisting of HCI design methods and selection approaches. Phase 2 is the categorisation of visualisation methods.

2.1. Phase 1: keyword search

This methodology began with keyword searches to identify books, websites, and journal and conference papers (using Google Scholar and Elsevier Scopus) that consisted of an inventory of HCI design methods and approaches to categorise these methods. A combination of HCI-related search terms were used: design, design process, Human-Computer Interaction (HCI), Interaction Design (IxD), methodology, pictorial, Service Design (SD), taxonomy, visualisation, user centric design, User Experience (UX). The resulting list of sources was reduced based on two criteria. Firstly, a source with 5 or less methods was not considered. Secondly, each source must provide either 1) detailed description of each design method or 2) a selection approach and show how a design method is categorised.

2.1.1. Determining a visualisation method

Design methods identified from the keyword search were first examined to group together duplicated methods. This included grouping together methods that are essentially the same but are named differently. For example, *Card Sort* is sometimes named as *Card Sorting*. As they are essentially the same method – involving the sorting of cards to elicit information from a target user – they were grouped together under *Card Sort*. Next, they were filtered to establish a list of methods that are identified in at least two sources. In some cases, a method was not considered even though it was identified in at least two sources. Methods with only two sources that are referenced from Design Council (n.d.a) and Design Council (n.d.b) were also omitted because the description provided were very similar in both websites. The methods omitted because of this were: *Choosing a Sample*, *Cluster and Vote*, *Comparing Notes*, *Drivers and Hurdles*, *Hopes and Fears*, *Project Space*, *Scribble-Say-Slap Brainstorming*, and *Workshop Toolkit*.

Based on the definition of a visualisation method clarified in Section 1, design methods that involved the formation of a 'graphical representation' were classified as a visualisation method. For example, *Card Sort* is considered as a visualisation method because it involves the organisation and grouping of cards to reveal information (Maguire, 2001). The 'graphical representation' is the resulting pattern of cards sorted into clusters. In contrast, *Heuristic Evaluation* is not considered as a visualisation method. Although *Heuristic Evaluation* is commonly used is HCI, this method only concerns an activity for evaluating an interface. At no point is a visual artefact created.

Fig. 2 shows how visualisation methods were derived in this research. In summary, this research started out with a keyword search to identify design methods for HCI. Subsequently, from this pool of design methods, those concerning the creation of a 'graphic representation' are considered as a visualisation method.

2.1.2. Deriving the categories within a selection approach

Different terminologies were sometimes used to describe the categories of a selection approach. To establish a coherent form of each selection approach, the varying terminologies were collated into a table so the key categories could be derived inductively. Detailed descriptions of each approach and their categories are presented in Section 3.2. A category was omitted if it did not fit the approach. For example, the *Visual Archetype* approach omitted *Games* and *Texts*. Similarly, the *Primary Purpose* approach omitted A*nalysing Research* and *Running Workshop*.

2.2. Phase 2: categorising visualisation methods

The visualisation methods are categorised based on evidence

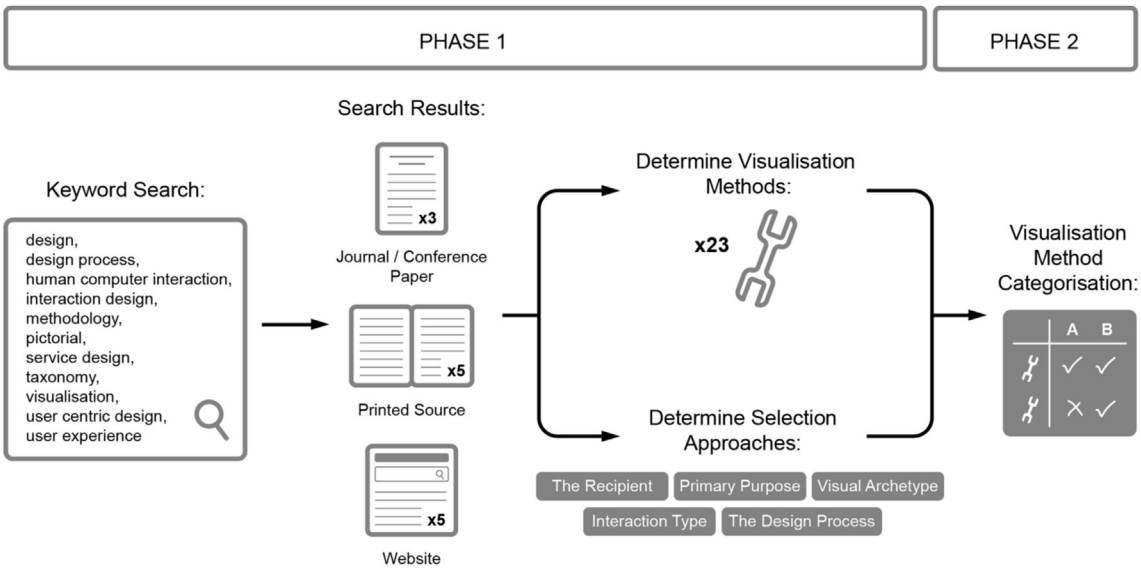

Fig. 1. Research methodology.

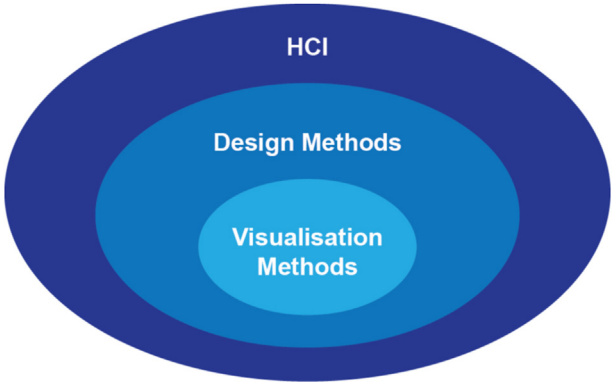

Fig. 2. A diagram to show the world view of the methods being studied.

identified in the literature. Appendix D presents a table of evidence supporting the categorisation of each method to the five approaches. Each method is categorised based on one or more of three types of evidence, 1) how it is previously categorised, 2) how it is described, 3) information inferred from its description.

As an example, Table 1 shows how *Card Sort* is categorised. In two approaches (*Primary Purpose* and *The Design Process*) *Card Sort* was placed in categorises where it has previously been categorised. It is categorised as *Designer* in *The Recipient* approach because, as evident in the text, this method is described as a method for designers to elicit information from users. For the *Visual Artefact* approach, this method is categorised in *Maps* based on information inferred from its description – the sorting of design attributes into groups suggests the data is being mapped. In the *Interaction Design* approach, this method is placed in *Learn* and *Ask*. It is placed as *Ask* based on how it has previously been categorised as *Learn* based on inference – after asking users to sort the cards the designer evaluates the results to derive meaning from it.

3. Visualisation methods and the approaches used for their selection

This section details the outcome of the methodology. Firstly, it presents the HCI visualisation methods identified in the literature. Secondly, it discusses the selection approaches that are being used to categorise these methods. Finally, it presents the categorisation of visualisation methods using each selection approach.

Table 1
Example of how Card Sort is categorised in each selection approach.

Selection approach	Category	Evidence
The Recipient	Designer	*Card Sort* is used by designers to evaluate how their target users understand and structure a set of concepts or information (Martin and Hanington, 2012; Maguire, 2001).
Primary Purpose	Explorative/ Generative	It has been categorised as *Generative* (Hanington, 2007) *and Exploratory*/*Generative* (Martin and Hanington, 2012).
Visual Artefact	Maps	Functions, features, and design attributes are presented on individual cards and are categorised into groups (IDEO, 2003; Usability Net, 2006).
Interaction Design	Learn/Ask	It has been categorised as *Ask* (IDEO, 2003). Two steps are associated with *Card Sort*; to sort the cards and the designer analysis of data resulted from the card sort (Fincher and Tenenberg, 2005).
The Design Process	Explore	It has been categorised as *Design* (Maguire, 2001), *Exploration*/*Concept Generation* (Martin and Hanington, 2012), and *Requirements* (Usability Net, 2006).

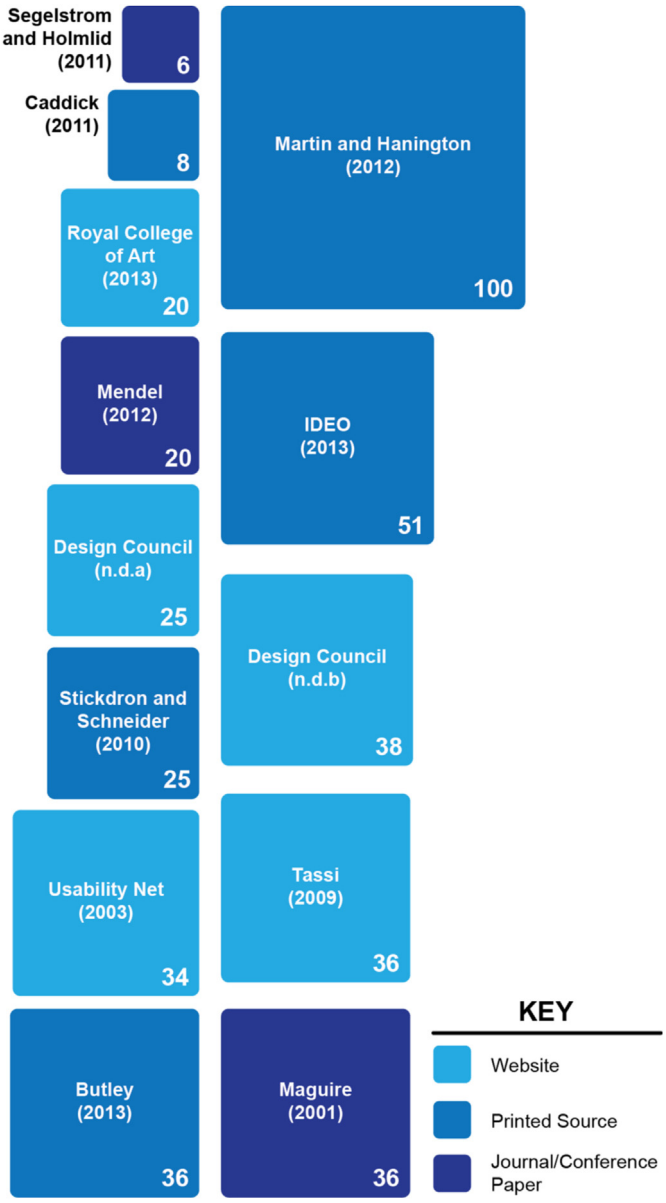

Fig. 3. The number of design methods identified from each source.

3.1. Visualisation methods

A total of 435 design methods were identified from 13 different sources. The total number of methods identified in each source is shown in Fig. 3. The size of the blue squares is proportional to the number of methods identified in each source. The number at the bottom right hand corner of each square is the number of methods identified from that source. The squares are colour coded based on the type of source (website, printed source, or journal/conference paper) in which they were obtained.

After grouping together similar methods (methods with the same purpose but are labelled differently), 245 individual methods were identified. To ensure sufficient information for each method to be put to use, only methods mentioned in two or more sources were retained. This reduced the total number to 57. The full list of HCI design methods are shown in Appendix A, along with the list of eliminated methods in Appendix B. From the 57 HCI methods, 23 were determined to be visualisation methods. The definition of each of the visualisation methods is provided in Appendix C. More information about each method can be obtained using the references provided.

3.2. Approaches to selection

This section presents the type of approaches used to categorise design methods. In this paper, the authors have chosen to provide illustrations of the different approaches through a catering setting. This is to provide an analogy of the roles and situations we may see in design development to help explain each approach. The chef represents the designer, who designs and creates a new product. The waiter represents the service provider, who makes sure the service runs smoothly and interacts with the customer. The role of the user is universal - a person that purchases and uses a product or service. The stakeholder can be represented by a restaurant owner who has investment and/or interest in the product or service. Thereby they have a say in the design and perhaps the implementation of the product or service.

The following sections present 5 selection approaches. They are illustrated and described in turn.

3.2.1. The Recipient

This approach helps designers to choose suitable methods that target a specific type of participant. As each participant has a different interest in the product and service, they would need different information about the final design. Table 2 shows the sources from which *The Recipient* approach was derived. Tassi (2009) suggests four types of recipients: *Stakeholder*, *Professional*, *Service Staff*, and *User*. The Royal College of Art (n.d.) came up with a variation of this approach. It focuses on people's relationships with the final design. They suggested three relationship types: whether the designing is conducted *For*, *With* or *By* the user. The RCA approach only tells us if the designer involves the users, but not to whom the results are directed towards. 'Conducted for users', does not mean that the recipient is the user.

Tassi (2009) did not provide a definition for the roles of the recipients. In this paper, the authors adapted Tassi's (2009) approach and define the types of recipients and their roles as follow (Fig. 4):

i. **Designer**: The person who designs the product or service.
ii. **Service Provider**: The person that would interact with the user to provide support for a product or service.
iii. **User**: The person that uses the final product or service.
iv. **Stakeholder**: The person whose interest would be affected by the outcome of the design.

3.2.2. Primary Purpose

Primary Purpose was developed by Hanington (2007) in their attempt to integrate human centred research within a design process (Table 3). This approach is adapted by Martin and Hanington (2012) in their book *Universal Methods of Design*. To use this approach, the designer needs to be aware of the information they have at hand and what they want to do with it. If they need to gain understanding or inspiration for an idea, that they are trying to gather more information, or if they are looking for new ways to help them arrange to find or understand the information they have.

There are three main purposes to design (Fig. 5):

i. **Exploratory**: Methods in this category help the designer to form knowledge based and empathy with people or situations in an unfamiliar territory.

Table 2
The variation of categories in The Recipient.

Source	The Recipient			
	Designer	Service provider	User	Stakeholder
Royal College of Art (n.d.)	With/By		For	
Tassi (2009)	Professional	Service Staff	User	Stakeholder

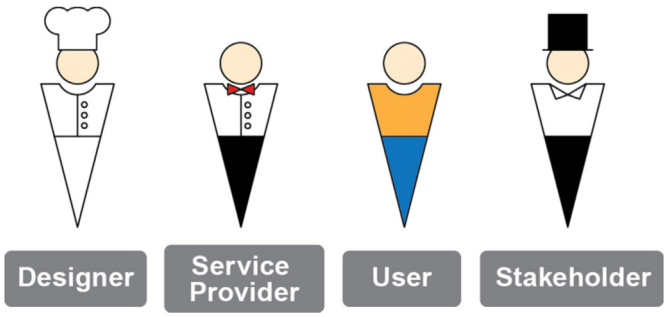

Fig. 4. The Recipient approach (adapted from Tassi, 2009).

Table 3
The variation of categories in Primary Purpose.

Source	Primary Purpose		
	Exploratory	Generative	Evaluative
Hanington (2007)	Exploratory	Generative	Evaluative
Martin and Hanington (2012)	Exploratory	Generative	Evaluative

ii. **Generative**: Methods in this category are used when users need to form a deeper understanding of people or situations. Concepts can be generated through participatory design activities.
iii. **Evaluative**: Evaluative methods are used to test design concepts against the user expectations.

This approach, to some extent, bares resemblance to *The Design Process* (Section 3.2.5); *Exploratory* is similar to *Explore*, *Generative* to *Create*, and *Evaluative* to *Implement & Evaluate*. However, *The Design Process* helps users to choose suitable methods based on the position or point in a design circle whereas *Primary Purpose* helps users to identify design methods based on their intention.

3.2.3. Visual Archetype

This approach is for categorising design methods based on their visual output. Diana et al. (2009) suggested that the main variables are: iconicity (how realistic the representation is) and the time factor (the relationship with time). The two extremes of iconicity are abstract and realistic. The two extremes of time are synchronic and diachronic.

Four visual archetypes can be identified when the two axes intersect, which can be used to categorise the visual output of design methods (Fig. 6). Each visual archetype is detailed as follows:

i. **Maps**: An abstract and synchronic representation. It is used to present an organised and comprehensive view of a design concept.
ii. **Flows**: An abstract representation with a pre-defined path that describes the design step-by-step.
iii. **Images**: A realistic representation of a design concept. Photographs are usually used to help evoke the emotion of a design.
iv. **Narratives**: A realistic representation that conveys the meaning of a design concept through 1) a sequence of images or 2) a person's interaction with the representation.

Diana et al. (2009) initially described *Narratives* as a category for methods that generate realistic representations that exert meaning through a sequence of images. This paper has extended the meaning of *Narratives* to include methods that require participants to 'perform' or 'act' using the visual artefact created. For example, the *Paper and Interactive Prototypes* method could result in the creation of a physical object or digital model. This visual artefact only exerts meaning when a person interacts with it. Hence this method was categorised in *Narratives*.

Mayas et al. (2013) and Tassi (2009) also describe similar categories based on the visual output of a method. Table 4 shows how their categories are associated with the categories in the *Visual*

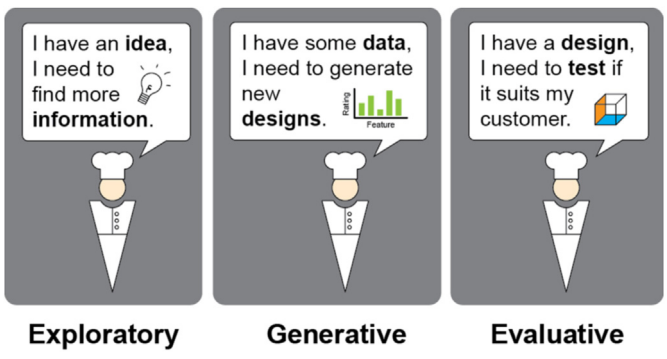

Fig. 5. The Primary Purpose approach (adapted from Hanington, 2007).

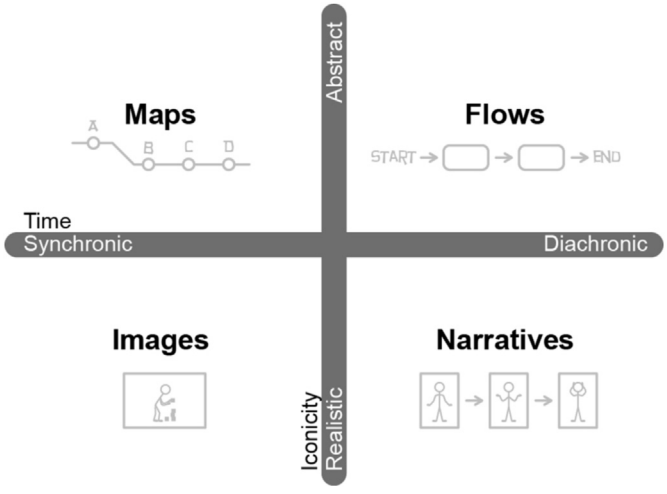

Fig. 6. The Visual Archetype approach (adapted from Diana et al., 2009).

Table 4
The variations of categories in Visual Archetype.

Source	Visual Archetype				Omitted
	Images	Maps	Flows	Narratives	
Diana et al. (2009)	Images	Maps	Flows	Narratives	
Mayas et al. (2013)	Pictorial or artifactual	Tabular	Diagrammatic	Narrative	
Tassi (2009)		Graphs		Narratives/Models	Texts/Games

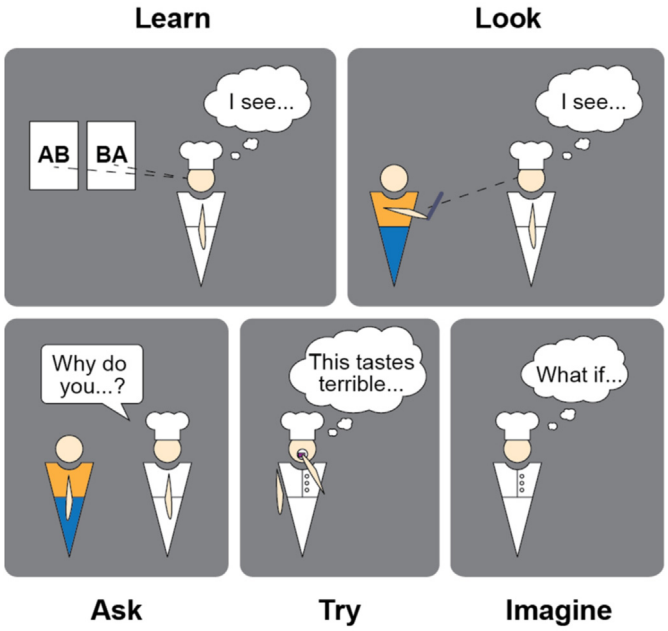

Fig. 7. The Interaction Type approach (adapted from IDEO, 2003 and Royal College of Art, n.d.).

Archetype approach.

The category *Games* was omitted because it refers to the activity rather than the visual outcome. The category *Texts* was also omitted because this paper was looking for approaches to categorise visualisation methods. Methods that purely rely on wording were not considered.

3.2.4. Interaction Type

The *Interaction Type* approach describes the type of activities that designers can undertake to address a design problem. For example, if a designer does not have the sufficient information to design the product. This approach provides a number of ways in which they can go about acquiring this information. The definition of each interaction type is as follows (Fig. 7):

i. **Learn**: To collect and analyse a set of information to identify new patterns and insights.
ii. **Look**: To observe how users behave to discover what they do rather than what they say they do because some people have difficulties expressing this information (Sanders and William, 2003).
iii. **Ask**: To recruit users' participation and obtain information relevant to the design project through inquiry.
iv. **Try**: To evaluate a design by creating simulations that enables designers to empathise with the end user.
v. **Imagine**: To explore and gain insight of how users might interaction with a speculative idea.

This approach was first developed by IDEO (2003), who identified four interaction types: *Learn*, *Observe*, *Ask*, and *Try*. In their online database, the Royal College of Art (n.d.) have categorised design methods based on the IDEO approach, but added an additional interaction type; *Imagine*. Saffer (2010) also described four approaches to interaction design. Table 5 shows how they are connected to the categories of the *Interaction Type* approach:

- *Activity Design* is to do with understanding the user's behaviour surrounding a task. This is similar to the *Look* category.
- *User-Centred Design* is to do with involving end users in the design process. This is similar to the *Ask* category.
- In *Genius Design*, design concepts are generated based on the experience of the design practitioner.
- *System Design* is omitted because it describes a holistic design approach, it does not correspond with any of the categories in *Interaction Type*.

3.2.5. The Design Process

The Design Process describes the stages of design. This approach allows designs to consider the method they can use for each stage of the design. This was the most popular approach used to categorise design methods - it was described in nine sources. Table 6 shows how nine different sources have described the stages of *The Design Process*. Most of the sources described the middle three stages. Rarely do they include the first (*Plan*) and last (*Monitor*) phrase as part of the process.

All the sources included *Explore* and *Create* to be key stages in this approach. The majority of the sources (8/9) identified *Implement & Evaluate* to be another key stage of this approach. As there were many variations to the name and stages of the design process, each variant was analysed to determine the main stages (Fig. 8):

i. **Plan**: This is the first stage of *The Design Process*. It is when a design would plan for the feasibility of the project, and to

Table 5
The variation of categories in Interaction Type.

Source	Interaction Type					Omitted
	Learn	Look	Ask	Try	Imagine	
IDEO (2003)	Learn	Look	Ask	Try		
Royal College of Art (n.d.)	Learn	Look	Ask	Try	Imagine	
Saffer (2010)		Activity	User-Centred		Genius	System

Table 6
The variation of categories in The Design Process.

Source	The Design Process				
	Plan	Explore	Create	Implement & evaluate	Monitor
Buley (2013)	Planning and discovery	Research	Design	Testing and validation	
Design Council (n.d.a)		Discover/Define	Develop	Deliver	
Maguire (2001)	Planning	Context of use/ Requirements	Design	Evaluation	
Martin and Hanington (2012)	Planning, scoping and definition	Exploration	Concept generation and early prototype iterations	Evaluation, refinement and production	Launch and monitor
Mendel (2012)		Discover/Reframe/ Envision	Create		
Royal College of Art (n.d.)		Discover/Define	Develop	Deliver	
Stickdorn and Schneider (2010)		Explore	Create and reflect	Implement	
Tassi (2009)		Co-designing/ Envisioning	Testing and prototyping	Implementing	
Usability Net (2006)	Planning and feasibility	Requirements	Design	Implementation/Test and measure	Post release

identify the scope and definitions. This stage is generally not considered part of *The Design Process* as only half of the sources considered *Plan* as a key stage.

ii. **Explore**: This stage is about forming an initial idea or perspective (Design Council, n.d.a; Stickdorn and Schneider, 2010). This can be done through learning from the subject matter or through gathering information.

iii. **Create**: This stage takes the findings from the previous stage to develop a solution. The solutions are tested to gain feedback for further development (Design Council, n.d.a).

iv. **Implement & Evaluate**: This stage is when the final concept is completed, produced, and launched (Design Council, n.d.a). The solution is evaluated based on the identified needs from previous stages of development.

v. **Monitor**: The last stage of *The Design Process* make sure the design is functioning as it should. Some designs may take longer before the success or failure can be determined. Problems identified later on could guide future designs.

3.3. Visualisation methods selection

This section presents how the visualisation methods are categorised in each approach and discusses the advantages and disadvantages for using each approach.

3.3.1. The Recipient

This approach guides designers to select the visualisation method that is suited for communicating with a certain recipient. This approach helps the designer to think about whom they are designing for or communicating design concepts with, thereby, tailoring the message to the audience. However, from Table 7, it is apparent that most of the visualisation methods are suitable to more than one recipient. In particular, the majority of the methods are suitable for the *Designer* (18/23), or *Stakeholder* (16/23). The vast number of methods in each category would make it difficult to narrow the choice of methods.

3.3.2. Primary Purpose

Primary Purpose enables designers to select a visualisation method based on the information they have at hand and what it is they would like to do with it. It is beneficial in that it helps designers to think about how they would proceed with the information they have. However, as there are only three categories in this approach, it would be difficult for designers to narrow down the choice of visualisation methods from their first selection. For example, if a designer has a concept with some initial data that they would like to communicate, they may look for a method in *Generative*. From Table 8 we can see there are 14 different methods in this category. As it is, designers would need to take the time to find out what each method does to select the most suitable one.

3.3.3. Visual Archetype

This approach is useful in that it informs the designer about the graphical style of each method. It categorises a visualisation approach based on how information will be structured for communication, and informs them of what the resulting artefact will look like. Nevertheless, methods with the same graphical style could be used to solve very different design problems. Methods

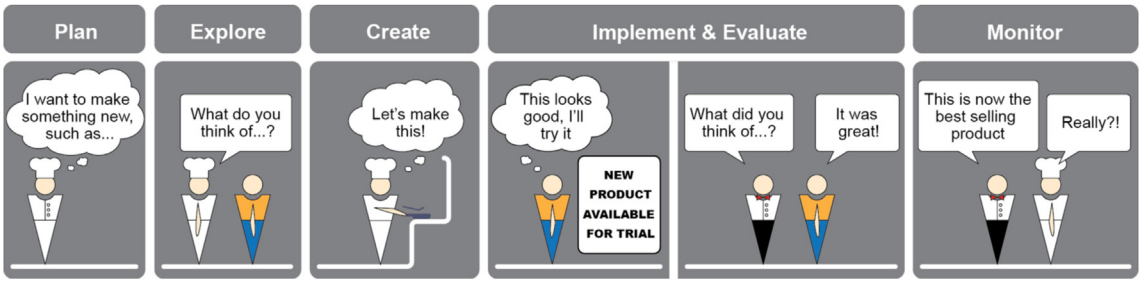

Fig. 8. The Design Process approach.

Table 7
Categorisation of visualisation methods using The Recipient approach.

Method	The Recipient			
	Designer	Service Provider	User	Stakeholder
A Day in the Life	•			
Affinity Diagram	•			•
Behavioural Mapping	•			
Blueprint	•			•
Card Sort	•			
Collage	•		•	
Customer/User Journey	•		•	
Desktop Walkthrough	•	•	•	•
Mind Map	•			•
Mood Board				•
Paper and Interactive Prototypes			•	
Persona	•			•
Photo Studies	•			
Poster				•
Process Model	•	•	•	•
Scenario	•	•	•	•
Service Prototype		•	•	•
Sketching	•	•	•	•
Stakeholders Map	•			•
Storyboard	•	•	•	•
Task Analysis	•	•		•
Task Mapping				•
Wireframe	•		•	•

categorised in the same category may have a similar format but the way in which the artefact is achieved and how information is derived from them could be very different. For example, *Mood Board* and *Photo Studies* are both placed in the *Image* category (Table 9). A *Mood Board* consists of a combination of images created by a designer to communicate a design concept. In comparison, for *Photo Studies*, the images are typically produced by end-users. These images are studied by designers to gain insights into a certain topic.

3.3.4. Interaction Type

This approach supports designers in determining how they would go about solving their design problem. It helps designers to first consider what the problem is (if they require insights of end users or to imagine design concepts), the resources they have access to (if they have access to end users or relevant stakeholders to gather information), and to derive the design activity they can employ.

Although this approach makes designers aware of the design activity they can perform it does not differentiate the context in which the activities are suited for. Consider the methods *Mind Map* and *Storyboard*. Both methods are categorised in *Imagine* (Table 10) - the category of methods that relies on the experience and imagination of the designer. Whilst *Mind Map* may be more suited for connecting related ideas and problems, *Storyboard* helps to communicate and present the key steps of an idea. To choose

Table 8
Categorisation of visualisation methods using the Primary Purpose approach.

Method	Primary Purpose		
	Exploratory	Generative	Evaluative
A Day in the Life	•		
Affinity Diagram		•	
Behavioural Mapping	•		
Blueprint		•	•
Card Sort	•	•	
Collage		•	
Customer/User Journey	•		•
Desktop Walkthrough	•	•	
Mind Map	•		
Mood Board		•	
Paper and Interactive Prototypes		•	•
Persona	•	•	
Photo Studies	•		
Poster		•	
Process Model	•		
Scenario		•	
Service Prototype			•
Sketching	•	•	
Stakeholders Map	•		
Storyboard		•	
Task Analysis	•		
Task Mapping		•	
Wireframe		•	•

Table 9
Categorisation of visualisation methods using the Visual Archetype approach.

Method	Visual Archetype			
	Images	Maps	Flows	Narratives
A Day in the Life				•
Affinity Diagram		•		
Behavioural Mapping		•		
Blueprint			•	
Card Sort		•		
Collage	•			
Customer/User Journey			•	
Desktop Walkthrough				•
Mind Map		•		
Mood Board	•			
Paper and Interactive Prototypes				•
Persona				•
Photo Studies	•			
Poster	•			
Process Model			•	
Scenario				•
Service Prototype				•
Sketching	•			
Stakeholders Map		•		
Storyboard				•
Task Analysis			•	
Task Mapping		•		
Wireframe		•		

Table 10
Categorisation of visualisation methods using the Interaction Type approach.

Method	Interaction Type				
	Learn	Look	Ask	Try	Imagine
A Day in the Life		•			
Affinity Diagram	•				
Behavioural Mapping		•			
Blueprint	•				•
Card Sort	•		•		
Collage			•		
Customer/User Journey			•		
Desktop Walkthrough				•	•
Mind Map	•				•
Mood Board					•
Paper and Interactive Prototypes				•	
Persona	•		•		•
Photo Studies	•		•		•
Poster					•
Process Model	•		•		
Scenario	•				•
Service Prototype				•	
Sketching	•		•		•
Stakeholders Map		•			
Storyboard					•
Task Analysis	•				
Task Mapping	•				
Wireframe				•	•

between these two particular methods, designers need to be aware of the nature of information they want to communicate.

3.3.5. The Design Process

This approach allows designers to plan the type of methods they would like to use at each stage of the design process. To use this approach, users will need to consider which stage they are at. However, in a similar way to the problem found in *Primary Purpose* and *The Recipient*, the majority of methods are categorised in *Explore* (22/23), which makes it difficult for designers to select this category.

Table 11 shows that *Affinity Diagram* is the most flexible method in that it can be used in four of the five categories (*Explore*, *Create*, *Implement & Evaluate*, and *Monitor*). Most of the methods are suitable for multiple stages of the design development. This means that it is possible to use the same method to further develop the design as it evolves in the design development. Usually when a method can be used in more than one category, they span across consecutive stages. For example, *Blueprint* can be used in *Create* and *Implement & Evaluate* (the stage that comes after *Create* in a design process). The only exception is *Task Mapping* which can be used in *Explore* and *Implement & Evaluate*, missing out *Create*. *Task Mapping* helps to sum up the required functions and tasks identified in the *Explore* stage, providing clear scope for design during *Implementation & Evaluation*.

The majority of the methods were categorised in the *Explore* stage, which is understandable considering that visualisation methods are used to communicate design ideas. There seems to be fewer methods in *Plan*, *Implement & Evaluation*, and *Monitor*. Visualising information is perhaps less useful or does not lend themselves as well to these stages.

Table 11
Categorisation of visualisation methods using The Design Process approach.

Method	The Design Process				
	Plan	Explore	Create	Implement & Evaluate	Monitor
A Day in the Life		•			
Affinity Diagram		•	•	•	•
Behavioural Mapping		•			
Blueprint			•	•	
Card Sort		•			
Collage		•			
Customer/User Journey		•			
Desktop Walkthrough	•	•	•		
Mind Map		•			
Mood Board		•			
Paper and Interactive Prototypes		•	•	•	
Persona		•	•		
Photo Studies		•			
Poster		•			
Process Model		•			
Scenario		•	•	•	
Service Prototype		•	•		
Sketching		•			
Stakeholders Map	•	•	•		
Storyboard		•	•	•	
Task Analysis		•	•		
Task Mapping		•		•	
Wireframe		•			

4. Discussion

In this paper we reviewed visualisation methods that can be used in HCI. From a total of 435 HCI methods, 57 were identified as common HCI methods. Twenty-three of these are further defined as visualisation methods.

Five approaches were found to categorise design methods: *The Recipient*, *Primary Purpose*, *Visual Archetype*, *Interaction Type*, and *The Design Process*. *The Recipient* approach categorises design methods based on who we are generating information for. It helps the designers to select methods depending on the level of detail they need to provide to the target audience. The *Primary Purpose* approach categorises methods based on the outcome that the designer is looking for. This approach can help the designer to select a suitable method depending on their desired end result. *Visual Archetype* categorises the methods depending on how realistic are the type of representations used in the method and whether they consist of a time element. This is the only approach that categorises design methods based on their outlook. The *Interaction Type* approach categorises design methods based on the type of action that designers could perform to gain further understanding of the design problem. *The Design Process* approach describes the stages of design. It informs the types of methods designers can use at each stage of design.

By categorising visualisation methods according to the selection approach, a number of advantages and disadvantages were identified. Each approach is unique for method selection, but it appears that they are not so effective individually. One problem is when there are a high number of methods categorised in one category. This is true, for example, in *The Design Process*. From Table 11, it can be seen that visualisation methods tend to be most suited for the *Explore* stage of a design process. This makes *The Design Process* approach ill-suited for categorising visualisation methods because it does not help a designer to narrow down the choice of visualisation methods. Without further intervention, designers would have difficulty in making a selection.

Even in approaches where the visualisation methods were better distributed, such as in *Visual Archetype* and *Interaction Type*, it is still not straightforward for the designers to make a selection. Deciding on the type of visual archetype (Section 3.3.3) they want to produce or how they want to approach a design problem (Section 3.3.4) is not enough because methods categorised in the same category could be used for very different purposes. Perhaps one way to overcome this issue is to use more than one selection approach. For example, as mentioned in Section 3.3.4, *Mind Map* and *Storyboard* are both categorised in *Imagine*. To distinguish between which methods to use, designers can refer to another a second approach such as *Primary Purpose*. If the designer would like a method for generating a design after imagining an idea, then the choice would be *Storyboard*. If the designer would like to imagine and explore possible design ideas, then *Mind Map* would be more suitable.

4.1. Limitations

In the search for HCI methods, only those mentioned in at least two of the 13 key sources were considered. Although some useful but lesser known methods may have been omitted, this step was necessary as over 400 methods were initially identified from the literature search. Focusing on methods that came from more than two key sources ensures that there are sufficient information a) for categorising the methods and b) for designers to employ less familiar method. To avoid neglecting methods that, in essence, perform the same tasks but are named differently, the authors had grouped together similar methods and provided their alternative names in Appendix A.

This paper focused on HCI visualisation methods in websites and published literature, which means that the methods identified may not necessarily be the most novel ones used by practising designers. Nevertheless, at the time of writing no inventory of HCI visualisation methods was established. Therefore, the authors deemed it important to first clarify what visualisation methods are commonly known in the literature. Only once this is determined then it can be used to enquire for methods missing from this initial study.

4.2. Future work

This paper has shown that each selection approach has its benefits and limitations. Individually, the selection approaches does not appear to be very effective when a large number of methods are categorised in one category. To choose between the methods, the designers must take time to differentiate between the methods as, currently, there is no mechanism to narrow down the choices. Future research could investigate the possibility of bringing together multiple approaches which could help to narrow down the choice of visualisation methods and improve the selection process.

One visualisation method on its own is not the be all and end all. Depending on the information they have at hand and what their design intentions are, a designer may require other methods to obtain the necessary information. For example, in choosing to use the *Storyboard* method, the designer will need to first consider if they have a clear picture of who their intended users are (Truong et al., 2006) and the story they are aiming to illustrate (Maguire, 2001). If the designer has little understanding of the end users, and decides that this information is important, then they may first employ another visualisation method such as *Personas*. Hence another factor to consider for future research is the procedure of each method. Providing addition information on the method procedure could help designers to quickly decide if it is a suitable method and whether or not they have the necessary resources for its application.

5. Conclusion

This research is significant because no research has studied the categorisation of visualisation methods in HCI. Although some studies have made an attempt in categorising design methods, they either had a broader focus (of methods for design in general), or have been in a specific discipline (such as service design) that is related but does not cover the whole of HCI. This research contributes to knowledge by 1) creating an inventory of visualisation methods used in HCI, 2) providing an analysis of the current approaches being used to categorise them, and 3) categorising the visualisation methods in each approach and discussing the advantages and disadvantages of each approach. As a result, this paper has produced an inventory of 23 visualisation methods and 5 different ways in which designers can choose to elect a suitable method. Two research questions are noted for future research, including: 1) further developing the method selection process to help designers narrow down the choice of methods effectively, and 2) to investigate the procedure for each visualisation method.

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Appendix A

Deriving Visualisation Methods From HCI Design Methods

		Source													Visualisation Method
		(Buley, 2013)	(Caddick, 2011)	(Design Council, n.d.a)	(Design Council, n.d.b)	(IDEO, 2003)	(Maguire, 2001)	(Martin and Hanington, 2012)	(Mendel, 2012)	(Royal College of Art, n.d.)	(Segelström and Holmlid, 2011)	(Stickdorn and Schneider, 2010)	(Tassi, 2009)	(Usability Net, 2006)	
1	A Day in the Life /Day in the Life					•				•		•			✓
2	Affinity Diagram /Affinity Diagramming					•	•	•					•	•	✓
3	Behaviour Mapping					•		•							✓
4	Being Your Users /Be Your Customer/Try it Yourself			•	•	•									
5	Blueprint /Service Blueprint			•							•	•	•		✓
6	Bodystorming					•		•							
7	Brainstorming														
8	Capability Simulators /Simulation Exercises/Empathy Tools				•	•		•							
9	Card Sort /Card Sorting					•	•	•						•	✓
10	Co-Creation /Participatory Design							•				•			
11	Cognitive Walkthrough							•					•		
12	Collage					•		•							✓
13	Competitive Product Survey /Competitive Testing/Competitor Analysis/Existing System					•	•	•						•	
14	Context /Context of Use Analysis						•							•	
15	Contextual Inquiry /Contextual Interview/Contextual Inquiry Interview				•			•				•		•	
16	Critical Incident Technique							•						•	
17	Cultural Probes							•		•		•			
18	Customer/User Journey /Customer Journey/Customer Journey Maps			•	•			•	•		•	•	•		✓
19	Design Guidelines /Design Guidelines and Standards						•							•	
20	Desktop Walkthrough /Business Origami/Scale Modelling					•		•			•	•			✓
21	Evaluative Research /Evaluative Prototype/Participatory Evaluation						•	•						•	
22	Experience Prototype /Experience Prototyping					•		•					•		
23	Five Whys?					•						•			
24	Fly on the Wall /Unobtrusive Measures/Field Study of Observation					•		•							
25	Focus Group			•	•		•	•		•				•	
26	Heuristic Evaluation /Heuristic or Expert Evaluation						•	•					•	•	
27	Ideas Generation Models								•			•			
28	Interviews /User Requirements Interview						•	•		•				•	
29	Mind Map							•					•		✓
30	Mood Board /Image Board				•			•					•		✓

(*continued on next page*)

(*continued*)

		Source														Visualisation Method
		(Buley, 2013)	(Caddick, 2011)	(Design Council, n.d.a)	(Design Council, n.d.b)	(IDEO, 2003)	(Maguire, 2001)	(Martin and Hanington, 2012)	(Mendel, 2012)	(Royal College of Art, n.d.)	(Segelström and Holmlid, 2011)	(Stickdorn and Schneider, 2010)	(Tassi, 2009)	(Usability Net, 2006)		
31	Observation /User Observation	•		•	•		•			•						
32	Paper and Interactive Prototypes /Prototypes/Physical Prototyping/Paper Prototyping/ Rough Prototyping/Rapid Prototyping/Quick and Dirty Prototyping	•		•	•	•	•	•	•	•			•	•	✓	
33	Parallel Prototyping /Parallel Design						•	•						•		
34	Persona /Character Profile		•					•	•	•	•	•	•		✓	
35	Personal Inventory					•		•								
36	Photo Studies /Camera Journal					•		•							✓	
37	Planning /Usability Planning and Scoping						•							•		
38	Poster /Predict Next Year's Headlines/Tomorrow Headlines					•							•		✓	
39	Process Model /Process Analysis								•	•					✓	
40	Questionnaires /UX Questionnaire/Satisfaction Questionnaire	•					•	•		•				•		
41	Role Playing			•	•	•		•	•	•		•	•			
42	Scenario			•	•	•		•	•	•		•	•	•	✓	
43	Secondary Research				•	•		•								
44	Service Prototype											•	•		✓	
45	Shadowing					•		•		•		•				
46	Sketching /Draw Your … /Draw the Experience/Fast Visualisation/Group Sketching	•		•	•	•							•		✓	
47	Stakeholders Map /Stakeholder Analysis/System Map						•	•			•	•	•		✓	
48	Story Telling															
49	Storyboard /Storyboarding						•	•			•	•	•	•	✓	
50	Survey /Survey & Questionnaires/User Survey/Survey of Existing Users/Quantitative Surveys			•	•	•	•	•						•		
51	Task Analysis /Cognitive Task Analysis/Task Model/Task Flow	•	•			•	•	•						•	✓	
52	Task Mapping /Function Mapping/Task Analysis Grid						•						•		✓	
53	Usability Testing /User Testing/Pleasure Based Approach							•					•	•		
54	Usability Test Report		•					•								
55	User Diaries /Diary Studies/Diary Keeping			•	•		•	•								
56	Wireframe	•	•												✓	
57	Wizard of Oz /Wizard of Oz Prototyping						•	•					•	•		

Appendix B

Design Methods Excluded From This Paper

		Source												
		(Buley, 2013)	(Caddick, 2011)	(Design Council, n.d.a)	(Design Council, n.d.b)	(IDEO, 2003)	(Maguire, 2001)	(Martin and Hanington, 2012)	(Mendel, 2012)	(Royal College of Art, n.d.)	(Segelström and Holmlid, 2011)	(Stickdorn and Schneider, 2010)	(Tassi, 2009)	(Usability Net, 2006)
1	A/B Testing							•						
2	Activity Analysis					•								
3	Actors Map												•	
4	AEIOU							•						
5	Agile Development											•		
6	Allocation of Function						•							
7	Anthropometric Analysis					•								
8	Artifact Analysis							•						
9	Assessment Criteria			•										
10	Assisted Evaluation						•							
11	Attitude Models								•					
12	Audit Framework								•					
13	Automated Remote Research							•						
14	Behavioural Sampling					•								
15	Behavioural Archaeology					•								
16	Black Hat Session	•												
17	Brainstorm Graphic Organisers							•						
18	Brand Borrowing				•									
19	Business Model Canvas											•		
20	Case Studies							•						
21	Choosing a Sample			•	•									
22	Cluster and Vote			•	•									
23	Cognitive Mapping							•						
24	Cognitive Maps					•								
25	Comparative Assessment	•												
26	Comparing Notes			•	•									
27	Comparison Frameworks								•					
28	Conceptual Landscape					•								
29	Concept Mapping							•						
30	Constructive Interaction												•	
31	Content Analysis							•						
32	Content Inventory & Audit							•						
33	Content Requirements		•											
34	Content Panorama												•	
35	Content Pattern	•												
36	Contextual Design							•						
37	Controlled User Testing						•							
38	Creative Toolkits							•						
39	Cross-Cultural Comparisons					•								
40	Crowdsourcing							•						
41	Customer Experience Audit							•						
42	Customer Lifecycle Maps											•		
43	Data Gathering and Organising Frameworks								•					
44	Design Brief	•												
45	Design Charette							•						
46	Design Conceptual Models								•					
47	Design Documentaries				•									
48	Design Ethnography							•						
49	Design Games												•	

(continued on next page)

(*continued*)

		Source												
		(Buley, 2013)	(Caddick, 2011)	(Design Council, n.d.a)	(Design Council, n.d.b)	(IDEO, 2003)	(Maguire, 2001)	(Martin and Hanington, 2012)	(Mendel, 2012)	(Royal College of Art, n.d.)	(Segelström and Holmlid, 2011)	(Stickdorn and Schneider, 2010)	(Tassi, 2009)	(Usability Net, 2006)
50	Design Principles	•												
51	Design Workshops							•						
52	Desirability Testing							•						
53	Diagnostic Evaluation													•
54	Directed Storytelling							•						
55	Dott 007				•									
56	Drivers and Hurdles			•	•									
57	Ecosystems								•					
58	Elito Method							•						
59	Emotional Timeline				•									
60	Energy Workshop				•									
61	Ergonomic Analysis							•						
62	Error Analysis					•								
63	Evaluating Existing System													•
64	Evaluation Walkthrough or Discussion						•							
65	Evaluation Workshop						•							
66	Everything-I-Touch				•									
67	Evidence-Based Design							•						
68	Evidencing												•	
69	Expectation Maps											•		
70	Experience Sampling Method							•						
71	Experiment							•						
72	Exploratory Research							•						
73	Extreme User Interviews					•								
74	Eyetracking							•						
75	Five−Second Test	•												
76	Flexible Modelling							•						
77	Flow Analysis					•								
78	Foreign Correspondents					•								
79	Funnel Diagram		•											
80	Generative Research							•						
81	Getting Started													•
82	Graffiti Walls							•						
83	Guerrilla Research	•												
84	Guided Tours					•								
85	Half a Profile				•									
86	Heuristic Markup	•												
87	Historical Analysis					•								
88	Hopes and Fears			•	•									
89	Identify Stakeholders						•							
90	Immersive Workshop									•				
91	Informance					•								
92	Interaction Table												•	
93	Interface Design Patterns													•
94	Intervention/Provocation									•				
95	ISO 13407													•
96	Issue Cards												•	
97	Kano Analysis							•						
98	Key Performance Indicators							•						
99	KJ Technique							•						
100	Laddering							•						
101	Lateral Thinking									•				
102	Learning Plan	•												
103	Lego Serious Play												•	

| | | |

(*continued*)

		Source												
		(Buley, 2013)	(Caddick, 2011)	(Design Council, n.d.a)	(Design Council, n.d.b)	(IDEO, 2003)	(Maguire, 2001)	(Martin and Hanington, 2012)	(Mendel, 2012)	(Royal College of Art, n.d.)	(Segelström and Holmlid, 2011)	(Stickdorn and Schneider, 2010)	(Tassi, 2009)	(Usability Net, 2006)
160	Style Guides													•
161	Subjective Assessment /Subjective Evaluation/Remote Evaluation													•
162	Territory Maps							•						
163	Thematic Networks							•						
164	Think-Aloud Protocol							•						
165	Time-Aware Research							•						
166	Time-Lapse Video					•								
167	Touchpoints Matrix												•	
168	Touchstone Tours							•						
169	Trend Maps								•					
170	Triading							•						
171	Triangulation							•						
172	Unfocus Group					•								
173	Usability Cost-Benefit Analysis						•							
174	Use Cases												•	
175	User Cost-Benefit Analysis						•							
176	User Forum									•				
177	User Journeys		•											
178	User, Usability and Organizational Requirements						•							
179	UX Health Check	•												
180	UX Project Plan	•												
181	Value Opportunity Analysis							•						
182	Weighted Matrix							•						
183	What's in the Fridge				•									
184	What a Wonderful World				•									
185	What If …											•		
186	Word Clouds							•						
187	Word–Concept Association					•								
188	Workshop Toolkit			•	•									

Appendix C

Visualisation Method Definition

	Method	Definition
1	A Day in the Life (Gillen et al., 2007; Samaroo et al., 2013)	This method enables designers to build up a realistic picture of what happens to their subject throughout a typical day. Visualising their daily activities, the time when it occurs (Royal College of Art, n.d.), and in the context where it occurs (IDEO, 2003), will help to reveal contextual information that may be missed otherwise (Stickdorn and Schneider, 2010).
2	Affinity Diagram (Holtzblatt et al., 2005; Kolko, n.d.)	This method is used to gather and organise large amounts of data, ideas, and insights (Diana et al., 2009). Starting with a problem statement, participants externalise their ideas by writing them on pieces of papers (Martin and Hanington, 2012). By identifying the connections between ideas, similar ideas could be clustered together to make sense of the information at hand (IDEO, 2003; Tassi, 2009).
3	Behaviour Mapping (Larson et al., 2005)	This method is used to reveal people's spatial behaviour in different locations (IDEO, 2003). Subjects are tracked based on their activity and time spent in a location and recorded using maps, architectural plans, video or time-lapsed photography (Martin and Hanington, 2012).
4	Blueprint (Bitner et al., 2008; Shostack, 1982)	A *Blueprint* is a schematic diagram for visualising the functions of a process from both the users' and service providers' perspectives (Stickdorn and Schneider, 2010). The process flow is organised into layers based on the actors involved (Segelström and Holmlid, 2011) to help each actor understand their role (Design Council, n.d.a). The line of visibility separates all the process that is visible to the user to the backstage processes. This helps to align the backstage process to the user experience (Tassi, 2009).
5	Card Sort (Fincher and Tenenberg, 2005; Petrie et al., 2011; Rugg and McGeorge, 1997)	A *Card Sort* is used to identify a person's mental model of a concept or idea (Usability Net, 2006). An unsorted list of items, which could be design features or functions, are created and participants would be asked to sort them into groups (Martin and Hanington, 2012). The results reflect the participant's understanding and expectations of the design attributes (IDEO, 2003; Usability Net, 2006).
6	Collage (Sanders and William, 2003)	A *Collage* involves a collection of images that can be used to communicate a user's thought, feelings and desires (Martin and Hanington, 2012). Users are asked to choose and arrange a collection of images. Explanation of their selection and arrangement provides designers with insights of the participant's thoughts and perceptions (IDEO, 2003).
7	Customer/User Journey (Diana et al., 2009; Kolko, n.d.; Yoo and Pan, 2014)	A *Customer/User Journey* provides a structured representation of a user's service experience (Segelström and Holmlid, 2011; Stickdorn and Schneider, 2010; Tassi, 2009). By capturing the step by step interactions of the user throughout a service it a) highlights touch-points or moments in the service to be evaluated and improved (Design Council, n.d.a, n.d.b; Martin and Hanington, 2012; Mendel, 2012; Tassi, 2009), and b) exposes the events that occur before and after an interaction to provide insights into the emotion triggers of users' experiences (Segelström and Holmlid, 2011).
8	Desktop Walkthrough (Fox, 2015)	The creation of a, usually paper, model of a setting allowing designers to test enact the service or product delivery. Low cost, miniature models representing people, artefacts, and the environment acts as tangible props to develop design ideas (Segelström and Holmlid, 2011; Stickdorn and Schneider, 2010; Martin and Hanington, 2012).
9	Mind Map (Buzan, 2011, 2014; Diana et al., 2009)	This method helps designers to extract out thoughts and their connections (Tassi, 2009). By starting with a problem or idea and building links around the starting point, this method helps to externalise information from the mind. This will allow the designer to clarify their thoughts and connect pieces of information that may, at first, seem to be unrelated (Martin and Hanington, 2012).
10	Mood Board (Diana et al., 2009; Mcdonagh et al., 2002; Moritz, 2005; Saffer, 2010)	*Mood Boards* provide a visual perception of the atmosphere, emotions, or inspirations of a design (Design Council, n.d.a). These are articulated to the audience through a composition of images, sketches, and materials (Martin and Hanington, 2012; Tassi, 2009).
11	Paper and Interactive Prototypes (Bailey et al., 2007; Houde and Hill, 1997; Lidwell et al., 2003)	*Paper and Interaction Prototypes* involve the creation of working models that transfer concepts into a tangible object, or experience in the context of use (Martin and Hanington, 2012). This allows designers and users to refine the design early on in the design process (Mendel, 2012) to avoid the risk of costly mistakes (Royal College of Art, n.d.). The fidelity of the prototype can vary throughout the design process (Mendel, 2012).
12	Persona (Cooper, 2004; Holtzblatt et al., 2005; Marshall et al., 2015; Nielsen, 2013; Pruitt and Grudin, 2003; Vincent and Blandford, 2014)	A *Persona* is used to represent the targeted end user (Design Council, n.d.b; Segelström and Holmlid, 2011; Stickdorn and Schneider, 2010). It is created from research, such as through observation or interview, of an archetype user (IDEO, 2003). A fictional character is generated based on the details identified from the research, such as their habits, social and

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Method	Definition
	demographic characteristics, their needs and desires, and cultural background (Caddick, 2011; Mendel, 2012; Tassi, 2009). The purpose of this method is to reveal patterns of behaviour so that designers can understand the user's lifestyle (Royal College of Art, n.d.). It acts as an artefact that reminds the design team of the type of user they are designing for (Tassi, 2009). By communicating the values of a typical user, this method can help in decision making and justifying ideas to others (Design Council, n.d.a). Although *Personas* describe a fictional person, they are based on real people. This method helps to humanises the design focus (Martin and Hanington, 2012).
13 Photo Studies (Sampanes et al., 2011)	*Photo Studies* are used to gain insight of users' activities in a less intrusive manner. Participants are asked to take photos of objects or environment according to set criteria. These photos are analysed by the designers to reveal their point of views or any patterns of behaviour (Martin and Hanington, 2012).
14 Poster (Gray et al., 2010)	A *Poster* is about foreseeing how the product or service idea will work in reality. This method requires the designers to think about what impact their design will have and whether it can sustain a customer base (IDEO, 2003). Envisaging the appearance and function of the design would make it more tangible and aids the communication and development between designers (Tassi, 2009).
15 Process Model (Martin et al., 2008)	This method is used to understand what happens in a process, which could be a task, transaction, activity or journey (Royal College of Art, n.d.). Through interview and observation, designers maps out the steps to a process. This is used to understand when activities happen and why (Mendel, 2012).
16 Scenario (Carroll, 2000; Suri and Marsh, 2000)	A *Scenario* can be written, drawn, or videoed (Design Council, n.d.a, n.d.b; Stickdorn and Schneider, 2010) account of a design concept from the user's point of view (IDEO, 2003; Martin and Hanington, 2012). The *Scenario* method make the design concepts "explicit and concrete" (Martin and Hanington, 2012, p.152) to discuss and explore the idea (Royal College of Art, n.d.; Stickdorn and Schneider, 2010).
17 Service Prototype (Saffer, 2010)	This method involves the enactment of a service delivery. Props are created and placed in where the service will eventually take place. This method is used to test how the service will function and identify whether any potential interference to the service delivery (Tassi, 2009). This method is useful because it can help designers to develop understanding of service scenarios that may be missed in written or visual descriptions (Stickdorn and Schneider, 2010).
18 Sketching (Hartson and Pyla, 2012; Rogers et al., 2011; Tovey et al., 2003)	*Sketching* involves the creation of simple drawings (Tassi, 2009) for eliciting experiences (Design Council, n.d.a, n.d.b; IDEO, 2003) or ideas (Buley, 2013; Design Council, n.d.b). It can be adapted in two ways: 1) it is used by a designer or the design team to explore and communicate what they are thinking (Buley, 2013), or 2) the designer could ask end users to make sketches based on a decided topic. The sketches produced helps the designer to understand the perceptions of the user (IDEO, 2003).
19 Stakeholders Map (Buckle et al., 2010; Gray et al., 2010)	A *Stakeholders Map* is used to provide an overview of the relationships and interactions between people within a work group (Martin and Hanington, 2012). The resulting visual representation is used to highlight issues concerning multiple users. By grouping these users together, effectively solutions can be sort to resolve to the problem (Stickdorn and Schneider, 2010).
20 Storyboard (Diana et al., 2009; Gray et al., 2010; Holtzblatt et al., 2005; Kantola and Jokela, 2007; Truong et al., 2006; van der Lelie, 2006)	A *Storyboard* consists of a series of drawings to present a sequence of events (Segelström and Holmlid, 2011; Stickdorn and Schneider, 2010). It is used to project the context in which an experience is formed as well as the key steps that make up the experience (Martin and Hanington, 2012; Tassi, 2009).
21 Task Analysis (Crystal and Ellington, 2004; Phipps et al., 2011; Rogers et al., 2011; Saffer, 2010)	A *Task Analysis* is used to show the stages that users have to go through to complete a task. At each stage, it presents what users do, how they expect to complete a goal (their behaviour), and the specific requirements at that stage. This helps designers to create a system that matches the user expectation (Caddick, 2011).
22 Task Mapping	*Task Mapping* is used to match the required function for different tasks and sub-tasks (Maguire, 2001). It helps to prioritise the importance of each function to exclude less important ones. This method presents the entire scope of the project and all the features in one place (Tassi, 2009).
23 Wireframe (Benyon, 2013; Hartson and Pyla, 2012; Rogers et al., 2011; Saffer, 2010)	A *Wireframe* is used present the design of a screen layout (Hartson and Pyla, 2012), specifically the content, the functionality, and the means to navigate to them (Saffer, 2010). It allows design teams to see if the data is structured correctly, how the functions will be developed, and how the page will be laid out (Caddick, 2011).

Appendix D

Evidence of Mapping

	Visualisation methods	Selection approach				
		The Recipient	Primary Purpose	Visual Archetype	Interactive Type	The Design Process
1	A Day in the Life	It has been categorised as *For*/*With* (Royal College of Art, n.d.). *A Day in the Life* is used by designer to gain understanding of what happens to their subject in a typical day (Royal College of Art, n.d.).	This method is used to gather information showing the activities of potential users throughout a day. It is used by designers to gain insight to the users' routines (Stickdorn and Schneider, 2010).	A user's routine can be depicted in varies ways. The use of simple drawings and comic strips are quick and inexpensive to produce. In comparison, photos and video provide more realistic and richer portrayals (Stickdorn and Schneider, 2010).	It has been categorised as *Look* (IDEO, 2003; Royal College of Art, n.d.).	It has been categorised as *Explore* (Stickdorn and Schneider, 2010) and *Discover* (Royal College of Art, n.d.).
2	Affinity Diagram	It has been categorised as *Stakeholders*/*Professionals* (Tassi, 2009).	It has been categorised as *Generative* (Martin and Hanington, 2012).	It has been categorised as *Graph* (Tassi, 2009) and *Maps* (Diana et al., 2009). This method is used to group together related topics or issues to reveal fundamental themes (Holtzblatt et al., 2005; Usability Net, 2006).	It has been categorised as *Learn* (IDEO, 2003). *Affinity Diagram* is used to analyse data gathered in research (Usability Net, 2006).	It has been categorised as *Co-designing* (Tassi, 2009), *Exploration*/*Concept Generation*/*Evaluation*/*Launch and Monitor* (Martin and Hanington, 2012), *Requirements* (Usability Net, 2006), and *Design* (Maguire, 2001).
3	Behaviour Mapping	*Behaviour Mapping* is used to extract patterns of behaviours for designers to gain better understanding of the target users (Larson et al., 2005).	It has been categorised as *Exploratory* (Martin and Hanington, 2012).	Human activities are recorded using "annotated maps, plans, video, or time-lapse photography" (Martin and Hanington, 2012, p.18).	It has been categorised as *Look* (IDEO, 2003). This method is for recording observations of location-based behaviours (Martin and Hanington, 2012).	It has been categorised as *Exploration* (Martin and Hanington, 2012).
4	Blueprint	It has been categorised as *Stakeholders*/*Professionals* (Tassi, 2009). *Blueprints* are best developed with a cross-functional team and could involve the input of the end users (Bitner et al., 2008).	This method is for detailing the interactions between different parties of a service (Design Council, n.d.a; Stickdorn and Schneider, 2010).	It has been categorised as *Graph* (Tassi, 2009) and *Flow* (Diana et al., 2009).	*Blueprints* facilitate the design and analyse of a service. They can be used to support refinement of a single step, or to create an overview of the entire service design (Bitner et al., 2008).	It has been categorised as *Testing and Prototyping*/*Implementing* (Tassi, 2009), *Create & Reflect*/*Implement* (Stickdorn and Schneider, 2010), and *Develop* (Design Council, n.d.a).
5	Card Sort	A *Card Sort* is used by designers to evaluate how their target users understand and structure a set of concepts or information (Martin and Hanington, 2012; Maguire, 2001).	It has been categorised as *Generative* (Hanington, 2007) *and Exploratory*/*Generative* (Martin and Hanington, 2012).	Functions, features, and design attributes are presented on individual cards and are categorised into groups (IDEO, 2003; Usability Net, 2006).	It has been categorised as *Ask* (IDEO, 2003). Two steps are associated with *Card Sort*; to categorise the cards and the analysis of data resulted from the card sort (Fincher and Tenenberg, 2005).	It has been categorised as *Design* (Maguire, 2001), *Exploration*/*Concept Generation* (Martin and Hanington, 2012), and *Requirements* (Usability Net, 2006).
6	Collage	A *Collage* is used by designers to elicit information end users. It involves asking people to arrange a set of pictures and words based on instructions determined by the designer (Sanders and William, 2003).	It has been categorised as *Generative* (Hanington, 2007) and *Generative* (Martin and Hanington, 2012).	This method makes use of images and photos. Participants are asked to select and arrange the images to compose collage (IDEO, 2003).	It has been categorised as *Ask* (IDEO, 2003).	It has been categorised as *Exploration*/*Concept Generation* (Martin and Hanington, 2012).
7	Customer/ User Journey	It has been categorised as *Stakeholders*/*Professionals* (Tassi, 2009).	It has been categorised as *Evaluative* (Martin and Hanington, 2012) and *Understanding Users* (Design Council, n.d.b).	It has been categorised as *Graph* (Tassi, 2009) and *Flow* (Diana et al., 2009).	A *Customer*/*User Journey* is used to map user experience. This information is established either through interviews or asking the users to create the map themselves (through blogging or video diaries) (Stickdorn and Schneider, 2010).	It has been categorised as *Envisioning* (Tassi, 2009), *Explore* (Stickdorn and Schneider, 2010), *and Define* (Design Council, n.d.a).
8	Desktop Walkthrough	A *Desktop Walkthrough* is used to analyse and test a service touchpoint. Models are used to provide a common language which enables various stakeholders to partake in the assessment (Stickdorn and Schneider, 2010, p.116).	It has been categorised as *Exploratory*/*Generative* (Martin and Hanington, 2012).	This method is used to test a service flow. The service delivery is enacted on a scaled model, which consists of key touchpoints. Tangible objects and people are often represented by figurines or drawn on with markers, so the service delivery can be enacted (Segelström and Holmlid, 2011, p.8).	It has been categorised as *Try* (IDEO, 2003). *Desktop Walkthroughs* let designers to visualise and try out a service design (Segelström and Holmlid, 2011)	It has been categorised as *Create & Reflect* (Stickdorn and Schneider, 2010) and *Planning*/*Exploration* (Martin and Hanington, 2012).

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	Visualisation methods	Selection approach				
		The Recipient	Primary Purpose	Visual Archetype	Interactive Type	The Design Process
9	Mind Map	It has been categorised as *Stakeholders*/*Professionals* (Tassi, 2009).	It has been categorised as *Exploratory* (Martin and Hanington, 2012).	It has been categorised as *Graph* (Tassi, 2009) *and Maps* (Diana et al., 2009).	*Mind Maps* are used to help the designer to clarify their thoughts and pieced together related information (Martin and Hanington, 2012).	It has been categorised as *Co-Designing* (Tassi, 2009) and *Exploration* (Martin and Hanington, 2012).
10	Mood Board	It has been categorised as *Stakeholders* (Tassi, 2009).	It has been categorised as *Having Ideas* (Design Council, n.d.b).	It has been categorised as *Narratives* (Diana et al., 2009) and *Image* (Diana et al., 2009).	*Mood boards* are used to explore how emotions are evoked in a product or service (Saffer, 2010).	It has been categorised as *Envisioning* (Tassi, 2009) and *Exploration* (Martin and Hanington, 2012).
11	Paper and Interactive Prototypes	It has been categorised as *For*/*With* (Royal College of Art, n.d.).	It has been categorised as *Generative*/*Evaluative* (Martin and Hanington, 2012) and *Prototyping* (Design Council, n.d.b).	*Paper and Interactive Prototypes* are working models that are used to explore or shows a design idea (Mendel, 2012).	It has been categorised as *Try* (IDEO, 2003; Royal College of Art, n.d.).	It has been categorised as *Concept Generation*/*Evaluation* (Martin and Hanington, 2012), *Design*/*Develop*/*Deliver* (Royal College of Art, n.d.), *Envision* (Mendel, 2012), *Design* (Maguire, 2001), *Testing and Validation* (Buley, 2013), and *Develop* (Design Council, n.d.a).
12	Persona	It has been categorised as *For*/*With* (Royal College of Art, n.d.) *and Stakeholders*/*Professionals* (Tassi, 2009).	It has been categorised as *Generative* (Martin and Hanington, 2012) and *Understanding Users* (Design Council, n.d.b).	It has been categorised as *Narratives* (Tassi, 2009).	It has been categorised as *Learn*/*Imagine* (Royal College of Art, n.d.) and *Learn* (IDEO, 2003). During development, Personas acts as reference for making design decisions (Caddick, 2011) and help designers to think about who the end users are, their needs, and the context in which the product or service will be used (Nielsen, 2013).	It has been categorised as *Envisioning*/*Testing and Prototyping* (Tassi, 2009), *Explore*/*Create & Reflect*/*Implement* (Stickdorn and Schneider, 2010), *Concept Generation* (Martin and Hanington, 2012), *Discover* (Royal College of Art, n.d.), *Discover* (Mendel, 2012), *Requirements* (Maguire, 2001) and *Develop* (Design Council, n.d.a).
13	Photo Studies	Designers ask users to take photos of their experience towards a product or service in order to gather insights of their behaviour and impressions towards that product or service (Martin and Hanington, 2012).	It has been categorised as *Exploratory* (Hanington, 2007).	Participants are asked to take photos of their experience towards a product or service (Martin and Hanington, 2012).	In *Photo Studies*, participants are invited to document, through taking photos, their experience regarding a service or product (IDEO, 2003; Martin and Hanington, 2012)	It has been categorised as *Exploration* (Martin and Hanington, 2012).
14	Poster	It has been categorised as *Stakeholders* (Tassi, 2009).	A *Poster* is used to project how a product of service idea, showing how the final design could be utilised and the impact it could have on the users (IDEO, 2003; Tassi, 2009).	It has been categorised as *Narratives* (Tassi, 2009) and *Image* (Diana et al., 2009).	It has been categorised as *Try* (IDEO, 2003).	It has been categorised as *Envisioning*/*Testing and Prototyping* (Tassi, 2009).
15	Process Model	It has been categorised as *For* (Royal College of Art, n.d.). Steps of a process are mapped out by designers, which can then be validated through interviews with experts of the process (Royal College of Art, n.d.).	This methods break down an existing activity into a sequence of steps (Mendel, 2012), this helps to understand the different parts of the process and their relationships (Royal College of Art, n.d.).	*Process Models* unravel a process into a sequence of activities (Mendel, 2012, p.83).	It has been categorised as *Learn*/*Ask* (Royal College of Art, n.d.).	It has been categorised as *Reframe* (Mendel, 2012) and *Discover* (Royal College of Art, n.d.).
16	Scenario	It has been categorised as *For*/*With*/*By* (Royal College of Art, n.d.). *Scenarios* should be tested with users or team members and refined from their feedbacks (Design Council, n.d.b).	It has been categorised as *Generative* (Martin and Hanington, 2012) and *Prototyping* (Design Council, n.d.b).	*Scenarios* can be written, drawn or a video of a design concept (Design Council, n.d.a, n.d.b; Stickdorn and Schneider, 2010).	It has been categorised as *Learn*/*Imagine* (Royal College of Art, n.d.) and *Try* (IDEO, 2003).	It has been categorised as *Exploration*/*Concept Generation* (Martin and Hanington, 2012), *Design*/*Develop*/*Deliver* (Royal College of Art, n.d.), *Requirements* (Maguire, 2001) and *Develop* (Design Council, n.d.a).
17	Service Prototype	It has been categorised as *Users* (Tassi, 2009). A *Service Prototype* involves creating the service design in a tangible form so it can be evaluated through enactment with client and stakeholders (Saffer, 2010).	The method is used to evaluate a service design (Stickdorn and Schneider, 2010; Tassi, 2009).	It has been categorised as *Models* (Tassi, 2009) and *Narratives* (Diana et al., 2009).	A *Service Prototype* is the physical creation of service features to enable enactment of the service delivery (Saffer, 2010, p.180).	It has been categorised as *Testing and Prototyping*/*Implementing* (Tassi, 2009) and *Create & Reflect* (Stickdorn and Schneider, 2010).

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	Visualisation methods	Selection approach				
		The Recipient	Primary Purpose	Visual Archetype	Interactive Type	The Design Process
18	Sketching	It has been categorised as *Service Staff/Users* (Tassi, 2009). *Sketching* is used to engage others to share your design ideas and to gain feedback (Buley, 2013). Asking users to drawing images of an experience or item can reveal perceptions that may be difficult to derive verbally (Design Council, n.d.b).	It has been categorised as *Having Ideas/Understanding Users* (Design Council, n.d.b).	Simple drawings of ideas (Buley, 2013; Design Council, n.d.a; Tassi, 2009) or experiences (IDEO, 2003) are resulted from this method.	It has been categorised as *Ask* (IDEO, 2003). *Sketching* does not just present drawing to look at, but the sketch acts as "a conversation between the sketcher and the artefact" (Hartson and Pyla, 2012; chap.7.7) in that it helps to evoke designs.	It has been categorised as *Co-Designing* (Tassi, 2009), *Design* (Buley, 2013), and *Discover* (Design Council, n.d.a). *Sketching* is a low-fidelity design method that is simple and quick to produce and modify. Therefore, they are ideal for exploring design variations (Rogers et al., 2011). *Sketching* is different to prototyping in that it is not used to refine a design, but to explore design ideas (Hartson and Pyla, 2012).
19	Stakeholders Map	It has been categorised as *Stakeholders* (Tassi, 2009).	It has been categorised as *Exploratory* (Martin and Hanington, 2012).	It has been categorised as *Graphs* (Tassi, 2009). A *Stakeholder Map* is used to create diagrams that define the roles, activities, and relations of people involved in the design project (Martin and Hanington, 2012).	*Stakeholder Maps* are used to visually depict who their stakeholders are and their relationship. This enables the design team to come up with strategies for engaging them (Gray et al., 2010).	It has been categorised as *Envisioning* (Tassi, 2009), *Explore/Create & Reflect* (Stickdorn and Schneider, 2010), *Planning, Scoping, and Definition* (Martin and Hanington, 2012), and *Requirements* (Maguire, 2001).
20	Storyboard	It has been categorised as *Stakeholders/Professionals/* Service Staff/Users (Tassi, 2009).	It has been categorised as *Generative* (Martin and Hanington, 2012).	It has been categorised as *Narratives* (Tassi, 2009) and *Narratives* (Diana et al., 2009). A *Storyboard* is "a short graphical depiction of a narrative" (Truong et al., 2006, p.12).	*Storyboards* can be presented to people in the design team or potential end users to help them visualise the end product and to gain feedback from them (Maguire, 2001).	It has been categorised as *Co-Designing/Envisioning/Testing and Prototyping/ Implementing* (Tassi, 2009), *Create & Reflect/Implement* (Stickdorn and Schneider, 2010), *Concept Generation* (Martin and Hanington, 2012), and *Design* (Maguire, 2001).
21	Task Analysis	Stakeholders, design team, and development team should be engaged in the development of the task model so they will have first-hand understanding of the end users (Caddick, 2011).	It has been categorised as *Exploratory* (Martin and Hanington, 2012).	A *Task Analysis* is shaped by "the flow of tasks to complete a goal" (Caddick, 2011, p.47).	It has been categorised as *Learn* (IDEO, 2003). A *Task Analysis* is produced from research. User testing can be conducted to validate the finished design, whether it is the final product or a prototype. The results can also be used refine the Task Analysis (Caddick, 2011).	It has been categorised as *Exploration* (Martin and Hanington, 2012), *Design* (Buley, 2013), and *Context of Use* (Maguire, 2001) A *Task Analysis* is used uncover the rationale behind how people complete a task. It is use to investigate in an existing situation rather than for envisioning new products or scenarios (Rogers et al., 2011).
22	Task Mapping	It has been categorised as *Stakeholders* (Tassi, 2009).	*Task Mapping* is used to clarity the type of function required for a product (Maguire, 2001).	It has been categorised as *Graph* (Tassi, 2009).	*Task Mapping* is used to define the required tasks (Maguire, 2001).	It has been categorised as *Implementing* (Tassi, 2009) and *Requirements* (Maguire, 2001).
23	Wireframe	A wide range of stakeholders could be included to discuss the content and functionality of the product (Caddick, 2011).	This method is for detailing an interface design (Caddick, 2011).	*Wireframes* allow the design team to see how content and features will be structured (Benyon, 2013; Caddick, 2011).	*Wireframes* are created to show how generic features are structured. The artefact produced can be evaluated with stakeholders (Benyon, 2013).	It has been categorised as *Design* (Buley, 2013). *Wireframes* are used in exploratory phases to create initial concepts of the interface (Rogers et al., 2011), or further along the design process to establish the detail of the design (Buley, 2013).

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